第 48 卷 第 10 期
2021 年 10 月

湖南大学学报（自然科学版）
Journal of Hunan University（Natural Sciences）

Vol. 48 No. 10
October 2021

Open Access Article

Water Availability Modelling for Supplying Domestic Demand

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Abstract: This research intends to build the water availability model for supplying the domestic demand in the Tambak Pocok small dam, Bangkalan, Indonesia. Domestic water demand is analyzed based on the population and the standard of water demand in the administrative service area. To estimate the eater availability from rainfall analyses is used the models of NRECA and F.J. Mock. However, for the process of water simulation and reservoir reliability during the 20 years projection period, the discharge data due to the F.J. Mock and NRECA is generated for 9 years by using the Thomas-Fiering method. Based on the simulation result of small dam reliability by carrying out the simulation process for every discharge data as the generated result along 20 years with the projection period during the 20 years, there is indicated that the discharge data by NRECA has been a failure on 2004, on 2007 with the reliability probability of 100%, and on 2026 with the reliability probability of 25%. However, the reliability probability is 100% from 2007 until 2026 for the whole discharge data simulation. Because there is no discharge data in the field, so the selection of discharge data is carried out by taking the Q_{min} for each discharge data of the two methods. Therefore, it is obtained that the small dam Q_{min} of F.J. Mock has a reliability degree of 100% from 2007 until 2026. However, for the small dam Q_{min} of NRECA, the small dam can still serve the whole population (100%) in 2007, for the next years is decreasing until 25% in 2026.

Keywords: National Rural Electric Cooperative Association, F.J. Mock, reservoir reliability.

供给国内需求的水资源可用性建模

摘要：本研究旨在为印度尼西亚邦加兰的丹巴波科小水坝建立满足国内需求的水资源可用性模型。生活用水需求是根据行政服务区的人口和需水标准来分析的。使用全国农村电力合作协会和莫克的模型从降雨分析中估计食者的可用性。然而，对于20年预测期内的水模拟和水库可靠性过程，由于莫克和全国农村电力合作协会的流量数据是使用托马斯-费林方法生成的9年。根据小坝可靠性的模拟结果，对每个流量数据进行模拟过程作为20年的生成结果和20年的预测期，表明全国农村电力合作协会的流量数据在2004年是失败的，2007年的可靠性概率为100%，2026年的可靠性概率为25%。然而，2007年至2026年整个放电数据模拟的可靠性概率为100%。由于现场没有放电数据，所以放电数据的选取是通过对两种方法的每个放电数据取问$_{分钟}$来进行的。因此，得出莫克的小坝问$_{分钟}$从2007年到2026年的可靠度为100%。但是，对于全国农村电力合作协会的小坝问$_{分钟}$，2007年小坝仍然可以服务全人口（100%），接下来几年将下降，直到 2026 年达到 25%。

关键词：全国农村电力合作协会，莫克，水库可靠性。

1. Introduction

Nowadays, human civilization development can not be free from the water function as one of the main supports in life. However, reminding to the water allocation and distribution on the earth that is not similar and proportional in the time and space [1]-[3], so the water structures availability for the water usage

Received: June 22, 2021 / Revised: August 23, 2021 / Accepted: September 29, 2021 / Published: October 30, 2021

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and control often becomes a must. Suppose a water source is decided to be developed for reaching a certain aim. In that case, there is needed a conception, plan [3], design, construction, and operation from any means for the usage and control [4], [5]. Design that is always based on accurate management and expertise is very urgent to reach the level of water usage usefulness necessary for the incoming period [6].

The flow patterns are influenced by factors such as the temporal and spatial distribution of hydraulics stream, rainfall, channel storage and watershed, soil characteristics and geology, cover condition, and watershed surface. The empirical relations are as the simple unsure or elements from which a hydrograph may be made as complex as needed. However, difficulties with the hydrograph development lie in the precise estimation of run-off from rainfall and the determination of flow paths [7], [8].

The design of a small dam is fully dependent on the planned water availability and demand, besides the topography condition and social in surrounding location as a consideration. Water availability is the ability of a river to supply a quantitative value throughout the year on the dry and rainy seasons to fulfill the number of designed outflow needs. However, the water presence needed from the planned outflow discharge can be achieved when the small dam is operated with the main component in fulfilling the aim of small dam development. This research intends to fulfill the domestic water availability for the village society of Tambak Pocok.

This research intends to investigate as follows: 1) How far the potency of water availability can be used for filling the storage of Tambak Pocok small dam?; 2) How much the outflow total that is issued by the Tambak Pocok small dam?; and 3) How much the probability of the storage reliability of Tambak Pocok small dam for fulfilling the domestic water availability that is designed during the incoming 20 years later?

2. Materials and Methods

2.1. Study Location

The study location is placed in the Bangkalan Regency, East Java Province, Indonesia. Geographically, the region is on the south longest of 6° 51’ 39’’ – 7° 50’ 39’’ and east longest of 112° 40’06” – 113° 08’ 04”. The total area of the Bangkalan Regency is ± 1,260.14 km² that consists of 18 districts. Map of location is presented as in Figure 1.

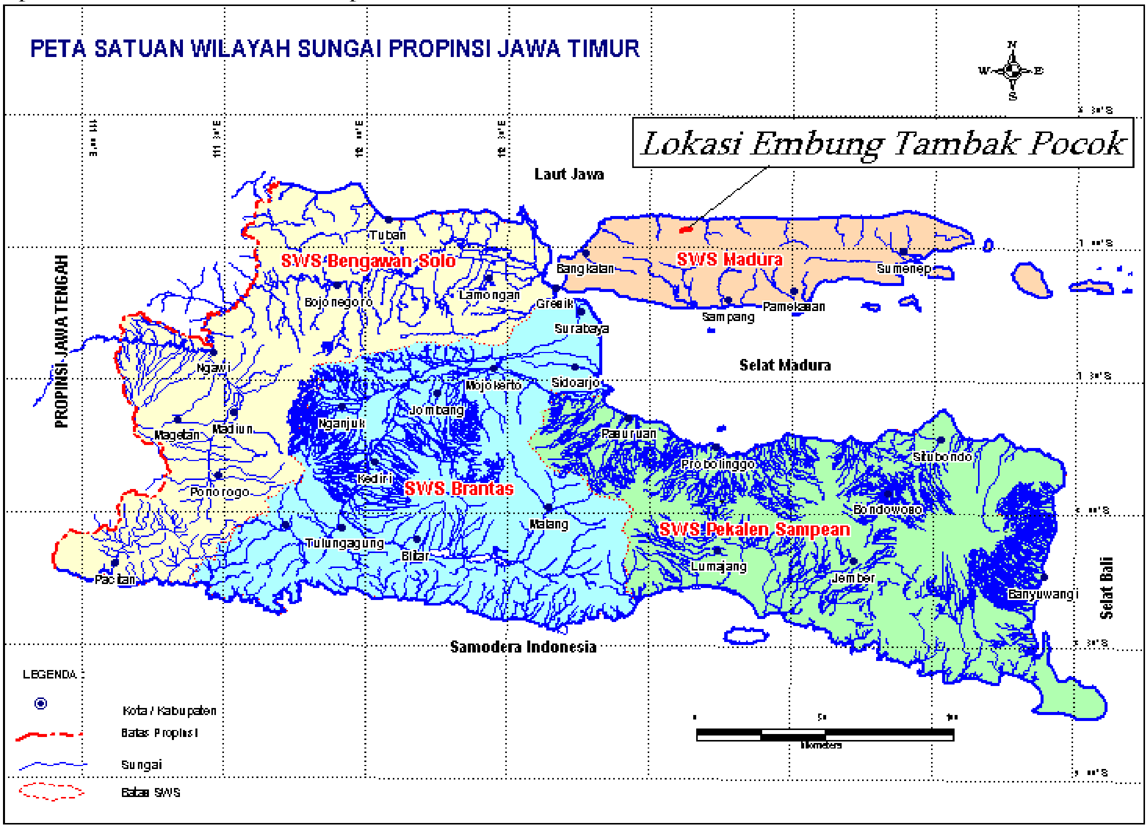

Fig. 1 Location of Tambak Pocok small dam

2.2. Existing Condition

2.2.1. Climate

The climate condition in a region is affected by the conditions of climate, topography, and geology. Climate affects the level of evaporation, temperature, humidity, wind velocity, and the sun shining. There is the condition of climate in the study location: the yearly average temperature is about 23.2° C and 35° C; the yearly average relative is in the amount of 96%; the daily wind velocity is in the average of 17.21 m/s; the yearly average evaporation is 4.84 mm/month; the yearly total maximum rainfall is 1,705 mm.

2.2.2. Research Data

This research needs secondary data. However, the secondary data are as follow:

a. The daily rainfall data from 1996 until 2006 from the 3 rainfall stations in the study location are Tanjung Bumi, Dupok, and Sepulu.

b. The climate data is obtained from the recording of monthly climate data from 1 climate recorded station in the study location that is the climate station. The secondary data is taken from the yearly climate report book in the Water Resources Department-East Java Province-Indonesia.

c. The data and Geology map from Geology Research and Development Center-Bandung that is Indonesia system Geology map-Lembar Tanjungbumi and Pamekasan 1609-2 and 1608-5 with the scale of 1:100,000

d. The regional topography map-Madura Lembar Tanjung Bumi 1609-211 from Bakosurtanal.

e. The social condition of society in the Bangkalan Regency and is obtained from Bangkalan in number 2006

f. The technical data of Tambak Pocok small dam.

2.2.3. The Steps of Research

The steps of research are as follow:

1. To analyze the monthly average rainfall.
2. To analyze the potential evapotranspiration by using the Modified Penmann method (FAO standard).
3. To analyze the parameter of NRECA and F.J. Mock regrading to the watershed characteristic data.
4. To analyze the water availability (river discharge) by using the methods of NRECA and F.J. Mock.
5. To generate the available discharge data as the results of F.J. Mock and NRECA during 9 years using the Thomas-Fiering method.
6. To analyze the domestic water need.
7. To simulate the small dam storage.
8. To analyze the reliability level of a small dam for operation regrading to the projection time.

2.3. The Basic Concept of Water Balance

The concept of water balance is basically to show the balance between the inflow to, the available in, and the outflow from the certain system (sub-system). Generally, the water balance is formulated as follows:

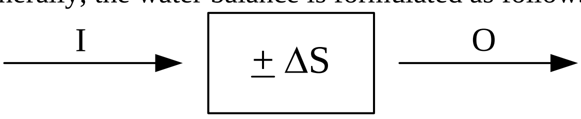

Fig. 2 The basic concept of water balance [9]

$$I = O \pm \Delta S \quad (1)$$

where:
I – inflow;
O – outflow.

Water balance is the relation between total inflow and total outflow that happens in a watershed containing components like river flow discharge, rainfall, evapotranspiration, percolation, soil humidity, and the time in it.

The water balance technique is one of the main subjects in hydrology. It is a way to obtain the important answer to the practical hydrological problems in the quantitative evaluation of regional water resources and the changes due to human activity. The information about the area and reservoir water balance for a certain time is needed to operate reservoir water management and the aim of hydrological estimation in general water management. The analysis of regional water balance is also important for comparing water resources potency between one region with the other region.

2.4. Flow Discharge by NRECA Method

The model of NRECA (National Rural Electric Cooperative Association) that was developed by Norman H. Crawford (USA) in 1985 [10] is the simplification of the Stanford Watershed Model IV (SWM) [11]. On the model of SWM, there are 34 parameters. However, the NRECA only uses 5 parameters. The NRECA model can be used for calculating the monthly discharge from monthly rainfall based on the water balance in the watershed. The formula of water balance is as follows: rainfall – actual evapotranspiration + storage change = run-off. The NRECA model divides the monthly discharge into 2 that are direct run-off (surface and sub-surface run-off) and base flow. However, the storage is also divided into 2 that are moisture storage and groundwater storage.

The rest of the rainfall flows over the surface, and the base flow moves into the river stream. Then the total available flow is multiplied with the watershed area; the result is the outflow of the NRECA model as the river flow discharge regarding the design period [12].

The total river flow discharge is calculated by using the formula as follow:

$$Q = (GF + DRF)xA \quad (2)$$

where:

A - watershed area (km^2)

DRF - direct run-off (mm)

= excm (1-PSUB), where Exc. = excess of moisture

Exc. = exrat x (P-AET)

GF = groundwater run-off (mm)

= GWF x (PSUB x Exc. = GWS)

exrat = ratio excess of moisture

= 0.5 x (1 + ((Sr-1)/0.52)), if Sr > 0

= 0, if Sr < 0

Sr = storage coefficient
= SMS /NOM
SMS = storage of soil moisture (NOM)
= capacity of moisture storage
= 100 + 0.2 x Ra; Ra = yearly mean rainfall (mm)
P = monthly rainfall (mm)
CROPF = Factor of sweat evaporation
Kl = (P/PET) x (1 -0.5 Sr) + 0.5 Sr
AET = actual evapotranspiration
= CROPF x PET, if P/PET> 1 or Sr >2
= (kl x PET) x CROPF, if P/PET < 1 or Sr < 2

2.5. Flow Discharge by F.J. Mock Method

Dr. F.J. Mock [13] introduced the simple model of monthly water balance simulation for flow that included the data of rainfall, evaporation, and the hydrology characteristic of the watershed. However, the potential evaporation and actual evapotranspiration are calculated as follows:

$$Ea = ETo - \Delta E \rightarrow (Ea = Et) \quad (3)$$

$$\Delta E = ETo \times (m/20) \times (18 - n) \rightarrow (E = \Delta E) \quad (4)$$

where:
Ea - actual evapotranspiration (mm/day);
Et - limited evapotranspiration (mm/day);
ETo - potential evaporation by Penman method (mm/day);
M - the area percentage that is not covered by vegetation, and it is estimated from the land use map;
m = 0 for the area with dense forest;
m = 0 for the area with the secondary forest at the end of the rainy season, and it is increasing by 10% every next dry season;
m = 10 – 40 % for erosion area;
m = 30 – 50 % for an agricultural area that is prepared, such as irrigated rice area, farm;
n - number of rainfall days in a month.

The rainfall that is reaching the soil surface can be formulated as follow:

$$Ds = P - Et \quad (5)$$

where:
Ds - rainfall that is reaching the soil surface (mm/day);
P - rainfall (mm/day);
Et - limited evapotranspiration (mm/day).

The formulations that are usef for groundwater are as follow:

$$V_n = k \cdot V_{n-1} + \tfrac{1}{2} (1 + k) \cdot I_n \quad (6)$$

$$DV_n = V_n - V_{n-1} \quad (7)$$

where:
Vn - volume of groundwater not-n;
V_{n-1} - volume of groundwater-(n - 1) ;
k = qt/qo = catchment area recession factor;
qt - groundwater flow on- t (month on-t);
qo - initial groundwater flow (month on-0);
In - infiltration on month-n;
DV_{n-1} - volume change of groundwater flow.

3. Results and Discussion

3.1. Balance Simulation of Small Dam Storage

Storage balance simulation includes 1 operation year or more. The operation pattern is divided into a period beginning from a monthly period, fifteen days, and ten days in the simulation process. The operation pattern period that will be used in the analysis of storage balance simulation is the monthly operation pattern. To be carried out, the storage balance is one of the reference points of water availability evaluation in the storage capacity of the Tambak Pocok small dam. In this research, the balance simulation scenario of discharge data generated during 20 years is carried out the balance simulation one by one to the change of domestic water need during the projection period of 20 years towards the two discharge data that are NRECA and F.J. Mock discharge. At the beginning of the simulation process, the storage of the Tambak Pocok small dam is assumed full with an effective storage capacity of 72,968.58 m^3, and the dead storage is 2,233.38 m^3. The calculation example of small dam storage simulation with Q_{min} by NRECA for January 2007 is as follows:

1. The inundation area of a small dam is obtained from the equation of the capacity curve
A = 16,221.17 m^2
2. Number of days: 31 days
3. Inflow: Qmin NRECA
: 0.0007 m^3/s
: (0.0007 x 3,600 x 24 x 31)= 1,770 m^3
4. Rainfall that enters into the small dam:
Mean rainfall 2006 x inundation area:
(205.67 x 16,221.17) / 1,000= 3,336.15 m^3
5. Total Inflow:
River discharge + rainfall that enters into small dam:
1,770 + 3,336.15= 5,106.15 m^3
6. Kebutuhan Air Baku:
Domestic water need on 2007:
174.24 m^3/day = 174.24 x 3,600 x 24 x 31= 5,401.44 m^3
7. Evaporation:
Mean evaporation x inundation area:
4.62 mm/day= (4.62/ 1,000) x 16,221.17 x 31= 2,323.19 m^3
8. Total Outflow:
Domestic water need + evaporation:
5,401.44 + 2,323.19= 7,724.64 m^3
9. Water balance (deficit):
Total inflow – Total outflow:
5,106.15 – 7,724.64= -2618,48 m^3
10. Small dam storage:
(Total inflow+ initial storage)–Total outflow:
(5,106.15 + 72,968.58) – 7,724.64= 70,350.10 m^3
11. End of storage:
Small dam storage + dead storage:

70,350.10 + 2,233.38 = 72,583.48 m^3

12. Spill out:

- If small dam storage < effective storage, so the spill-out = 0
- If small dam storage > effective storage,

So the spill-out = small dam storage – effective storage

13. The probability of operation:

- If small dam storage < dead storage, so the operation = failure
- If small dam storage > dead storage, so the operation = success

The analysis of storage balance simulation is made by the recapitulation result pattern every year, and there is presented in Tables 1-5.

3.2. Simulation of Small Dam Storage Reliability

A small dam can be said reliable if the small dam can guarantee the minimum demand needed. In the simulation of small dam storage, reliability will be seen if the condition of available small dam storage capacity fulfills the planned design needs along the year with the failure risk that has been calculated. The reliability analysis is obtained from the small dam operation pattern every month that what it experiences failure or success for operating to fulfill the need that has been planned in the analysis of small dam storage simulation result.

The change of small dam end storage capacity for the simulation process every year has an inter-correlation. For example, the small dam end storage for December 2007 will fill the small dam initial storage in January 2008 until the end simulation period during 20 years. The initial storage capacity will affect the simulation process of small dam storage that experiences the success or failure operation process. The recapitulation result of simulation during 20 years for the discharge data due to the F.J. Mock method can fulfill the small dam storage for operation process in 100%. However, for simulation due to the NRECA method, there is a failure for the operation during the simulation for the whole simulation in 2004, at the beginning of small dam storage operation, it fulfills the operation pattern in 100% from 2007 until 2008, but for the next, it experiences the decreasing until 42% that is on 2026.

In this research, because there is no measuring discharge data, so on the two discharges due to the NRECA and F.J. Mock is found the Q_{min} and is carried out the simulation process of small dam storage. On the Q_{min}, the discharge due to the F.J. Mock is carried out the storage balance simulation and experiences the operation process in 100%, however on the Q_{min} due to the NRECA method, the operation pattern of small dam storage experiences the process in 100% at the beginning of the operation, and it is decreasing until 25% on 2026. The selection of taking the Qmin for the operation pattern due to the probability of Q_{min} often happens remembering that the climate and geology condition in the Tambak Pocok region on the dry season is experiencing very dry. The usage of the NRECA model for the continuous process cannot be so satisfied because may be the number of parameters less good remembering that the model structure is in the soil moisture zone, which is very seasonal, so for the continuing model, the mean nominal usage is difficult to obtain the optimal simulation discharge due to the parameter is also affected by rainfall condition during one year. However, the usage of the F.J. Mock model for finding the soil moisture zone is very dependent on the land use and rainfall condition.

Based on the recapitulation result of the simulation, there is still a small dam water surplus on the wet month, so the water surplus can be used for irrigating the moor that is cropped by corn. The fulfillment of the water need for corn is taken about 0.6 l/s/ha. However, this assumption is based on the cropping pattern result on the existing Mandadirada small dam-Sumenep [14]. Therefore, it is made the analysis result of water surplus by using the discharge condition of $Q_{50\%}$, $Q_{70\%}$, $Q_{80\%}$, $Q_{90\%}$, and Qmin. For the water surplus on the $Q_{50\%}$, the area ability can be fulfilled for each discharge data: NRECA and F.J. Mock 28 ha and 49 ha. For $Q_{70\%}$, the area that can be irrigated is an amount of 9 ha for NRECA and 29 ha for F.J. Mock. For $Q_{80\%}$, the area ability to irrigate is 1.3 ha for NRECA and 19 ha for F.J. Mock. For $Q_{90\%}$, the area ability to irrigate is 0 ha for NRECA and 7 ha for F.J. Mock. On the water surplus of Q_{min}, the area ability that can be irrigated is 0 ha for NRECA and 2.7 ha for F.J. Mock. The recapitulation is presented in Tables 1-5.

Table 1 The usage of $Q_{50\%}$

No	Year	NRECA							
		Water availability (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	627,386.18	63.60	2,904.00	563.79	surplus	100.00	18,921.60	29.80
2	2011	627,386.18	69.05	3,153.00	558.34	surplus	100.00	18,921.60	29.51
3	2016	627,386.18	76.54	3,495.00	550.85	surplus	100.00	18,921.60	29.12
4	2021	627,386.18	84.84	3,874.00	542.55	surplus	100.00	18,921.60	28.68
5	2026	627,386.18	94.04	4,294.00	533.35	surplus	100.00	18,921.60	28.19
No	Year	FJ MOCK							
		Water availability (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	1,023,216.77	63.60	2,904.00	959.62	surplus	100.00	18,921.60	50.72
2	2011	1,023,216.77	69.05	3,153.00	954.17	surplus	100.00	18,921.60	50.43
3	2016	1,023,216.77	76.54	3,495.00	946.68	surplus	100.00	18,921.60	50.04
4	2021	1,023,216.77	84.84	3,874.00	938.38	surplus	100.00	18,921.60	49.60
5	2026	1,023,216.77	94.04	4,294.00	929.18	surplus	100.00	18,921.60	49.11

Table 2 The usage of $Q_{70\%}$

No	Year				NRECA				
		Water availibility (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	277,294.26	63.60	2,904.00	213.70	surplus	100.00	18,921.60	11.30
2	2011	277,294.26	69.05	3,153.00	208.24	surplus	100.00	18,921.60	11.01
3	2016	277,294.26	76.54	3,495.00	200.75	surplus	100.00	18,921.60	10.61
4	2021	277,294.26	84.84	3,874.00	192.45	surplus	100.00	18,921.60	10.18
5	2026	277,294.26	94.04	4,294.00	183.26	surplus	100.00	18,921.60	9.69
No	Year				FJ MOCK				
		Water availibility (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	65,677.54	63.60	2,904.00	594.07	surplus	100.00	18,921.60	31.40
2	2011	65,677.54	69.05	3,153.00	588.62	surplus	100.00	18,921.60	31.11
3	2016	65,677.54	76.54	3,495.00	581.13	surplus	100.00	18,921.60	30.72
4	2021	65,677.54	84.84	3,874.00	572.83	surplus	100.00	18,921.60	30.28
5	2026	65,677.54	94.04	4,294.00	563.63	surplus	100.00	18,921.60	29.79

Table 3 The usage of $Q_{80\%}$

No	Year				NRECA				
		Water availibility (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	118,253.57	63.50	2,904.00	54.66	surplus	100.00	18,921.60	2.89
2	2011	118,253.57	69.05	3,153.00	49.20	surplus	100.00	18,921.60	2.61
3	2016	118,253.57	76.54	3,495.00	41.71	surplus	100.00	18,921.60	2.21
4	2021	118,253.57	84.84	3,874.00	33.41	surplus	100.00	18,921.60	1.77
5	2026	118,253.57	94.04	4,294.00	24.22	surplus	100.00	18,921.60	1.28
No	Year				FJ MOCK				
		Water availibility (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	468,726.83	63.60	2,904.00	405.13	surplus	100.00	18,921.60	21.42
2	2011	468,726.83	69.05	3,153.00	399.68	surplus	100.00	18,921.60	21.13
3	2016	468,726.83	76.54	3,495.00	392.19	surplus	100.00	18,921.60	20.73
4	2021	468,726.83	84.84	3,874.00	383.89	surplus	100.00	18,921.60	20.29
5	2026	468,726.83	94.04	4,294.00	374.69	surplus	100.00	18,921.60	19.81

Table 4 The usage of $Q_{90\%}$

No	Year				NRECA				
		Water availibility (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	61,848.07	63.60	2,825.00	-1.75	deficit	97.28	0.00	0.00
2	2011	61,848.07	69.05	2,825.00	-7.203	deficit	89.60	0.00	0.00
3	2016	61,848.07	76.54	2,825.00	-14.692	deficit	80.83	0.00	0.00
4	2021	61,848.07	84.84	2,825.00	-22.993	deficit	72.92	0.00	0.00
5	2026	61,848.07	94.04	2,825.00	-32.191	deficit	65.79	0.00	0.00
No	Year				FJ MOCK				
		Water availibility (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	232,734.45	63.60	2,904.00	169.14	surplus	100.00	18,921.60	8.94
2	2011	232,734.45	69.05	3,153.00	163.68	surplus	100.00	18,921.60	8.66
3	2016	232,734.45	76.54	3,495.00	156.19	surplus	100.00	18,921.60	8.26
4	2021	232,734.45	84.84	3,874.00	147.89	surplus	100.00	18,921.60	7.82
5	2026	232,734.45	94.04	4,294.00	138.70	surplus	100.00	18,921.60	7.34

Table 5 The usage of Q_{min}

No	Year				NRECA				
		Water availibility (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	61,848.07	63.60	2,825.00	-1.75	deficit	97.28	0.00	0.00
2	2011	61,848.07	69.05	2,825.00	-7.203	deficit	89.00	0.00	0.00
3	2016	61,848.07	76.54	2,825.00	-14.692	deficit	80.83	0.00	0.00
4	2021	61,848.07	84.84	2,825.00	-22.993	deficit	72.92	0.00	0.00
5	2026	61,848.07	94.04	2,825.00	-32.191	deficit	65.79	0.00	0.00
No	Year				FJ MOCK				
		Water availibility (m3)	Domestic water need (m3)	serviced population (person)	Difference (m3)	Note	Storage reliability (%)	Irrigation water need (m3)	serviced area (ha)
1	2007	232,734.45	63.60	2,904.00	169.14	surplus	100.00	18,921.60	8.94
2	2011	232,734.45	69.05	3,153.00	163.68	surplus	100.00	18,921.60	8.66
3	2016	232,734.45	76.54	3,495.00	156.19	surplus	100.00	18,921.60	8.26
4	2021	232,734.45	84.84	3,874.00	147.89	surplus	100.00	18,921.60	7.82
5	2026	232,734.45	94.04	4,294.00	138.70	surplus	100.00	18,921.60	7.34

4. Conclusion

Based on the analysis and discussion above, it can be concluded as follows:

1. The river flow discharge availability is analyzed due to the F.J. Mock method and NRECA with the parameter as follow: a) F.J. Mock method with the assumption that the infiltration coefficient is 0.3, the factor of groundwater recession is 0.5, and the soil moisture is 200 mm, and b) NRECA method with the assumption that the coefficient of flow is 0.5 and the coefficient of groundwater flow is 0.5. The flow discharge availability is due to the 2 methods as follow: a) Mean discharge (in volume) is 698,487.63 m^3 for NRECA and 1,193,856.03 m^3 for F.J. Mock; b) $Q_{80\%}$ is 118,253.57 m^3 for NRECA and 468,726.83 m^3 for F.J. Mock; c) $Q_{90\%}$ is 61,848.07 m^3 for NRECA and 232,734.45 m^3 for F.J. Mock, and d) Qmin is 39,722 m^3 for NRECA and 146,567.24 m^3 for F.J. Mock.

2. Volume total outflow from Tambak Pocok small dam for domestic water need fulfillment at the beginning of operation 2007 is 63,597.60 m^3 for fulfilling 2,904 persons and for the next 10 years such as 2016 is 76,540.50 m^3 with the domestic water need fulfillment for 3,495 persons, however for the next 20 years such as on 2026 is 94,038.60 m^3 for fulfilling 4,294 persons.

3. Based on the analysis result of storage reliability by using the storage operation simulation. The Tambak Pocok small dam can still fulfill the water need in Tambak Pocok village until 2026 in 100% for the discharge condition of $Q_{50\%}$, $Q_{70\%}$, $Q_{80\%}$, $Q_{90\%}$, Q_{min} due to the F.J Mock method with the probability of reliability in 100%. However, due to the NRECA method, the need fulfillment can only in 100% fulfilled with the discharge of $Q_{50\%}$, $Q_{70\%}$, $Q_{80\%}$, for the discharge of $Q_{90\%}$, and Q_{min} is needed from the other source for the water need fulfillment. The fulfillment of domestic water need that is taken as the probability of 100% and the storage reliability is 100% too, so the risk value for happening the inflow into the small dam storage has the small risk with the small discharge too.

Based on the analysis, the value of water surplus is still enough. The water surplus is very potential to be used for domestic need as well as moor need. However, the level of water needs fulfillment has not been maximal, mainly for the low water discharge condition and dry season water discharge condition due to the NRECA method.

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